EVALUATING CONSTRUCTION ACTIVITIES IMPACTING ON WATER RESOURCES: PART 1

GUIDELINES FOR CONSTRUCTION OF HYDROCARBON TRANSMISSION AND DISTRIBUTION PIPELINES CROSSING WATERCOURSES

March, 1984

Ministry of the Environment
Ontario

EVALUATING CONSTRUCTION ACTIVITIES IMPACTING ON WATER RESOURCES: PART I

GUIDELINES

FOR

CONSTRUCTION OF HYDROCARBON TRANSMISSION AND DISTRIBUTION PIPELINES CROSSING WATERCOURSES

March, 1984

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FOREWORD

In 1976, the Ontario Ministry of the Environment (MOE) published the handbook "Evaluating Construction Activities Impacting on Water Resources" to be used in the assessment of the environmental impacts of construction activities. The environmental impacts from construction were poorly understood at that time and it was indicated that the handbook would be revised as new information became available. The considerable experience gained since 1976 now warrants that the original publication be revised to reflect current knowledge.

These guidelines for the construction of transmission pipelines crossing watercourses form the first of five parts of the revised 1976 handbook. The remaining parts, each published as a separate volume, deal with highways and bridges; dredging and spoils disposal; marine construction; and small scale construction projects.

Hydrocarbon transmission and distribution pipeline projects in the Province of Ontario require the approval of an application by either the Ontario Energy Board (OEB) or the National Energy Board (NEB). All MOE concerns regarding such projects are forwarded to the OEB for inclusion, along with the concerns of other review agencies, in a coordinated response to a project application from a proponent. In most cases, then, proponents will make initial contact with the OEB to establish application procedures and regulations.

From a water resources perspective, many of the most critical concerns associated with pipeline construction arise during crossings of streams and lakes, where poorly planned construction activities often lead to excessive sediment production. The following document, therefore, concentrates on the watercourse crossing aspects of pipeline construction as they relate to the production of sediment. It has been prepared solely to outline fundamental principles and to specify those watercourse crossing considerations which may best assist proponents and MOE staff in (a) evaluating the potential adverse impacts of pipeline watercourse crossings, and (b) planning adequate mitigative measures.

INTRODUCTION

Good construction practice for watercourse crossing of transmission pipelines must ensure that every effort be made to preserve the physical and biological integrity of Ontario's waterbodies in accordance with the Provincial goals -- "To ensure that the surface waters of the Province are of a quality which is satisfactory for aquatic life and recreation" (Ontario Ministry of the Environment, 1978).

Each crossing must be examined on a site-specific basis; general characteristics such as size and flow are not in themselves reliable indicators of watercourse sensitivity. For this reason, arbitrary categorization of crossing techniques according to stream size is unacceptable. Care must be taken to ensure that each watercourse to be crossed is studied in sufficient detail to allow the best decision to be made regarding crossing technique and post-construction stabilization measures. The director of an MOE region may require that an appropriate water quality monitoring program be implemented for crossings of watercourses designated as "sensitive" by local MOE offices.

Watercourse crossings should strive for minimal impacts on water quality and water use by achieving:

1. the shortest possible construction time during the season of least disturbance;
2. limited instream disturbance; and
3. immediate implementation of post-construction stabilization measures.

The initial sections of the document provide background information on pipeline construction and associated adverse impacts of sedimentation. Subsequent sections outline a series of recommendations for the avoidance of common construction-related problems (and the rationale for these recommendations), and

environmental study report requirements pertaining to watercourse crossings. Finally, the implementation of environmental protection measures through contract specifications is outlined and a brief discussion of monitoring programme objectives is provided (for those crossings where they are deemed necessary).

1. OVERVIEW OF PIPELINE CONSTRUCTION OPERATIONS

Construction of transmission pipelines involves a variety of operations, many of which have the potential to produce large quantities of sediment. Details of these operations will depend on the size of the project, site specific conditions, and the contractor(s) involved. For the purposes of these guidelines, however, a series of general operations have been listed and defined below. Those which have the potential to increase sedimentation as the result of nearstream or instream erosion have been labelled.

OPERATION	DESCRIPTION
Clearing and Grubbing*	A variety of equipment is used to remove trees, stumps, and vegetation from the right-of-way (ROW).
Trenching*	Topsoil is selectively removed and stockpiled for use during site restoration and excavation equipment is used to cut the pipeline trench to required specifications (blasting may be required). Excavated material is usually stockpiled for use as backfill although in certain instances material will be trucked away and granular material will be brought in.
Preparation of Pipe	The pipe is hauled in from stockpiles and placed end to end, next to the trench. Where necessary a pipe bending machine is used to bend the pipe to required specifications.

OPERATION	DESCRIPTION
Welding, Cleaning and Coating	The pipe segments are aligned and welded to form a continuous line and rust and dirt are cleaned from the exterior of the pipe. It is then coated and inspected for coating faults.
Lowering-In	The pipe is placed in the trench.
Backfilling*	Damaged tiles (or those removed during construction) in nearstream agricultural areas are replaced, and the trench is selectively backfilled so that no material capable of damaging the pipe coating is placed against the pipe.
Hydrostatic Testing**	A mechanical scraper is sent through the pipe to remove rust, scales, and dirt, then water is pumped into the pipe until a designated pressure is achieved. If this pressure is maintained for the allotted test period (e.g. 24 or 48 hours) the line is considered acceptable and the water is discharged. If a leak is indicated through a loss of pressure, it is located and repaired and the line is retested.

Clean-up and Restoration	Construction-related debris is removed from the ROW and the area is restored to as near preconstruction conditions as possible.

* denotes operations having potential to increase sedimentation due to instream or nearstream erosion.

** certain applications may employ airpressure testing

2. IMPACTS OF CHANNEL EROSION AND SEDIMENTATION

Both instream and nearstream work have the potential to release large amounts of sediment which, if not controlled at the source, will be introduced into the watercourse. Depending on the grain sizes of the sediment and the watercourse flow, sediment may settle to form a bed deposit, become entrained as bedload, or become entrained as suspended load. In most cases a combination of the three occurs.

This chapter first examines the effects of sediment on the abiotic water environment and then discusses the resulting impacts on aquatic biota and watercourse users. It concludes with an assessment of sediment control practices.

2.1 Effects of Sediment on the Abiotic Water Environment

There will be both short-term and long-term effects on the aquatic environment associated with the construction and operational phases of pipeline watercourse crossings.

2.1.1 Short-Term Effects

Short-term effects are usually easily observed since instream and nearstream construction activity is concentrated in one location over a relatively short period of time. Large quantities of sediment may be almost instantaneously introduced into the watercourse, blanketing the channel bed and filling the water column with suspended particles. This has the potential to alter the light, temperature and water chemistry regimes of the watercourse. The downstream extent of the disruption will depend upon the individual watercourse, but in many cases effects are discernible at considerable distances from the original crossing site.

2.1.2 Long-Term Effects

Long-term sediment related effects tend to be secondary and are, therefore, usually less attributable to specific activities than short-term effects. They result from alteration to the regime of the watercourse due to local changes in bed and bank morphology and composition (i.e. altered depth, width, gradient, size of bed material).

Morphological changes induce altered flow patterns which in turn disrupt the local scour and fill (i.e. short-term in-channel erosion and deposition) equilibrium. In this way the effects can be transmitted both upstream and downstream, potentially altering conditions well removed from the point of initial disturbance.

The composition of bed and bank material can be altered by the introduction of imported backfill material, deposition of trench sediments, and the action of altered flow patterns.

The potential for long-term effects should not be overlooked and can be minimized through careful attention to site rehabilitation. The goal should always be to restore all disturbed areas at the crossing to as near preconstruction conditions as possible.

2.1.3 Sediment Chemistry

In some cases pesticides, herbicides, oil and grease, and other hazardous chemicals bonded to the sediment may be encountered during trench excavation. Although the risk of contaminant uptake by organisms and subsequent biomagnification through the food chain is less in those instances where contaminated sediments have been covered by clean deposits, trenching may reintroduce the contaminated material into the water column making it directly available to the ecosystem. It is, therefore, desirable to restrict bed disturbances to as small an area as possible.

In areas of known or suspected contamination the material to be removed during the trenching operations must be disposed of according to MOE's spoils disposal guidelines (Ontario Ministry of the Environment 1976).

2.2 Sedimentation Impacts on Aquatic Biota

The sedimentation effects of watercourse crossing will tend to result in certain adverse impacts on aquatic biota. For the purposes of the following discussion, the complex and interrelated components of the stream ecosystem have been separated into:

(a) primary productivity;
(b) benthic organisms; and
(c) fish.

However, interference with any part of the system has the potential to disrupt the stability of the entire system.

2.2.1 Primary Productivity

The photosynthetic production of organic matter by green plants e.g. plankton, algae etc. (autotrophs) is referred to as primary productivity. The increased turbidity (see Appendix I for definition), which results from the introduction of suspended sediment into the water column, attenuates the penetration of light and curtails photosynthesis, thereby adversely affecting one of the basic food sources of the aquatic environment. In those cases where in-channel vegetation is affected, a loss of protective cover may also result.

In order to prevent unnecessary adverse impacts upon primary productivity, every effort should be made to reduce the extent and duration of turbid conditions. This is best achieved by limiting construction in and adjacent to watercourses to the absolute minimum.

2.2.2 Benthic Organisms

The survival of benthic organisms depends upon the preservation of the watercourse substrate as suitable habitat. The most severe impact of sediment on the benthic community is the blanketing of the channel bed as the result of rapid sediment deposition. This either destroys the organisms or causes them to drift downstream (Hynes 1973). These bottom dwellers form a vital link in the aquatic food chain and dependent predators will be forced to abandon any region thus affected.

2.2.3 Fish

Increased turbidity adversely affects those species of fish which rely on sight for feeding and escaping from predators. Excessive sediment levels may also affect the respiratory mechanism of fish through clogging or abrasion of the gills although many species of adult fish are able to withstand high levels for extended periods of time by exuding a protective mucous on their skin and gills. Their survival is not assured, however, since the production of this mucous depletes their metabolic reserves at a time when the location of food is inhibited by the turbid conditions (Illinois EPA 1979).

Sediment can also clog the interstices of the substrate in fish spawning areas thereby interfering with the normal exchange of water which replenishes the oxygen supply and removes accumulated waste products. This impact can be lethal to emerging young (Illinois EPA 1979).

The loss of reproductive capacity through physiological stress, loss of spawning beds, and destruction of fry may result in a more significant negative impact on fish species than the direct short-term abrasion and clogging effects on adult fish. Although the damaged habitat may recover eventually, recolonization may be by less desirable species.

2.3 Impacts on Watercourse Uses

In addition to disrupting aquatic biota the turbidity resulting from construction-related sediment loads may also adversely affect various types of watercourse uses. These are summarized below.

2.3.1 Impaired Municipal/Industrial Water Supply

Depending on the extent and duration of turbid conditions and associated contaminants, and the treatment facilities available, there may be a temporary impairment or loss of water supply for municipal and/or industrial users. In some instances increased operational costs may result (e.g. increased backwashing) and equipment or facilities may be damaged creating a longer term disruption.

2.3.2 Flow Obstruction/Increased Flood Risk

Flow obstruction results from the formation of bars due to sediment deposition and can occur in channels of all sizes and types. The reduction in channel capacity through sediment accumulation may also be exacerbated by other types of construction debris. An increase in the frequency of overbank flows is the most common consequence of flow obstruction. These may inflict water and sediment damage on adjacent property and structures.

2.3.3 Damage to Artificial Structures

The long-term changes in scour and fill processes which may accompany short-term sedimentation effects can lead to the failure of such structures as bridges and culverts, while nearby structures may be endangered by bank failures.

2.3.4 Impaired Recreational Use

Both short-term and long-term effects have the potential to disrupt downstream recreation. Direct use of a water body for activities such as swimming will be curtailed by short-term increases in suspended sediment levels or other aesthetic parameters which result in an unpleasant appearance. Indirect uses, such as stream bank parks and trails, will suffer from such long-term effects as the loss of aesthetic value due to bank failures, and unsightly erosion and sediment control measures (e.g. concrete channel, gabion baskets).

2.4 Control of Construction Sediment

In the past, efforts to minimize erosional losses from areas of active construction have employed various control measures with varying degrees of success. The following extract, from a Ministry of the Environment study, reflects experiences to date with various control devices.

> A review of the existing data from the limited number of stream crossings that have been monitored indicates that some water quality degradation is inevitable. Many of the techniques employed to date (notably instream sediment traps) to minimize that degradation have been unsuccessful and only prolonged the construction period. Monitoring of properly carried out wet crossings suggests that the magnitude and duration of suspended sediment levels are not a direct threat to fish. By keeping the duration of construction to an absolute minimum it should be possible to keep the sediment load to the stream small enough to avoid habitat modification and burying of benthic invertebrates (Ontario Ministry of the Environment 1981).

This study suggests that the most important factor in the production of sediment from pipeline crossings is the amount of in-stream construction time, and that the best sediment control approach is to reduce this time to the absolute minimum. By reducing the quantity of sediment introduced into the watercourse the impacts of the previously outlined sediment-related effects can be diminished.

For streams that are particularly sensitive (downstream water uses, fish spawning activity, etc.) it may be necessary to adopt a "dry" crossing. Available evidence suggests that this technique is successful if the stream has a relatively stable low flow, the soils in the trench are sufficiently impervious that dewatering is practical and that care is taken with all other phases of the crossing.

3. RECOMMENDATIONS FOR REDUCTION OF WATERCOURSE CROSSING IMPACTS

This chapter outlines a series of recommendations which, if carefully applied, will help minimize the impacts of watercourse crossings on water resources. As indicated, reduction of instream work time is a fundamental objective and recommendations 1, 2, 3, 6, 7, 10, and 17 are directly related to this goal.

The section following the recommendations provides suggestions for the preparation of environmental study reports for pipeline projects, and the chapter concludes with a proposal for contract specifications and implementation to ensure that the recommendations are carried out.

3.1 Recommendations and Rationale

1. Comprehensive site-specific information should be compiled to allow adequate planning for route selection, construction techniques, mitigative measures, and site restoration (see Section 3.2).

   Many of the problems which arise during pipeline construction are the result of insufficient planning which fails to prepare the contractor for field conditions and which causes costly and environmentally damaging delays. A common example is the discovery, during trenching, of hard subsurface material where, according to a superficial field survey, none was thought to occur. In this case additional equipment is required and the crossing schedule must be altered to accommodate blasting (which must be timed to avoid impacts on fish migration or other water users). This type of delay, which occurs after instream work is under way, causes unnecessary increased erosion of cleared and cut areas.

   Local well records or geophysical survey data can often provide useful hints on subsurface conditions to be encountered although boreholes may be necessary in some instances.

2. Appropriate equipment should be selected in advance to facilitate the rapid execution of the crossing operation.

Contractors should not use equipment which is poorly suited to the specific crossing (e.g. too small, too large, too heavy, with insufficient reach etc.). In such cases, the equipment used must often operate from the stream bed or be transferred from one bank to the other causing further delay and resulting in degradation to both banks and bed.

3. Clean backfill material should be stockpiled onsite to eliminate delays in areas where native material is not suitable for backfill.

In cases where native material is not suitable as backfill it is common for the trench to be left unprotected until suitable material can be hauled in. This may lead to continuous erosion of the trench, or the sides of the trench may slump; in either case remedial work will be required, extending the construction period and potentially interfering with the post-construction stabilization schedule (if construction is extended into fall or winter the planned stabilization measures may be inadequate and increased erosional damage will occur during spring runoff).

4. The decision to use sediment traps should be based on very careful planning since their use may create more problems than solutions.

Over the last few years various devices have been used as sediment barriers including: snow fence with filter fabric, metal "A" frames with filter fabric, straw bales, and sandbag flumes. These have been unsuccessful from the standpoint of water quality protection and in many cases have resulted in significantly greater environmental damage than well planned,

swiftly executed wet crossings. For this reason general use of sediment traps is not recommended.

5. The method of stream crossing should be based on a site-specific evaluation.

   In determining the appropriate method of stream crossing, including selection of "wet" or "dry" methods, it will be necessary to evaluate all relevant factors. These will include: streamflow, stream width, environmental sensitivity, soil composition, streambank stability, and approach slope.

6. Dredging operations should not be conducted on prime recreational lakes during periods of peak use.

   Restriction on dredging operations is necessary in order to avoid degradation of water quality and aesthetic value by dredge related turbidity and to avoid physically restricting the movement of recreational boating. Where applicable the work may be scheduled to coincide with low water conditions (e.g. following annual drawdown).

7. Comprehensive pre-construction investigations and consideration of construction techniques should be undertaken in areas where sensitive materials, such as Leda clay, are likely to be encountered.

   The areas of Southeastern Ontario corresponding to the pre-glacial Champlain Sea (Ottawa Valley and St. Lawrence Valley) contain subsoils of marine origin. Many of the clay beds laid down at that time have a high water content and poor structure and as a result tend to fail when disturbed. The watery mass which results is both highly unstable and erodible. Unless adequate planning has resulted in the implementation of specific measures, construction activity can be severely hampered and an extreme amount of sediment can be introduced into the watercourse.

8. All site operations should be monitored and approved by an environmental inspector familiar with the construction plans and schedules for the specific project (see Section 3.3).

Inspection will ensure that the contractor complies with all design details and special provisions for environmental protection. It is imperative that the design details and special provisions be based on a thorough pre-construction investigation so that unexpected conditions do not result in major changes to construction plans. Both the inspector and contractor should review and familiarize themselves with the plans prior to activity in the field.

Minor changes, such as the substitution of one form of stabilization for another, can be accommodated in the field. However, they must be approved by the environmental inspector as being capable of achieving the same environmental management goal set out in the original construction plans. (For further detail see Section 3.3 Contract Specifications and Environmental Protection.)

(It is advisable that prior to the start of construction, site meetings be held between the proponent, the contractor, environmental inspector and government personnel to confirm site specific plan commitments).

9. Rapid completion of post-construction site restoration should be undertaken in order to minimize soil loss, especially during spring runoff.

Wherever possible, construction should be planned to allow completion sufficiently early in the growing season for vegetative stabilization measures to be put in place. In some areas (e.g. on very steep slopes or areas with highly erodible soils), additional measures will be required (e.g. mulches, chemical stabilization, nylon matting, etc.) until vegetative cover is firmly established.

If work is restricted to late in the season because of potential conflict with water uses (e.g. fisheries, recreation) during the summer season, special stabilization measures will be required. This will be especially important on steep banks and other sensitive slopes. Selected nursery stock and chemical soil binders should be employed immediately following construction to provide protection until spring planting, which will provide maximum erosion control.

Detailed arrangements regarding interim and final stabilization should be covered in the contract specifications and under no circumstances should a site be abandoned without the installation of adequate stabilization measures.

Planning for stabilization should incorporate as much geotechnical information as possible since the degree of difficulty associated with vegetative or structural re-stabilization of a site will determine construction technique. Steep or long slopes in combination with unstable soil will necessitate special construction techniques such as tunnelling, and will preclude any approach involving significant ground vibration such as blasting, since restabilization after the failure of such slopes will be difficult.

10. <u>The backfilled trench should conform to the pre-construction channel configuration and excess material should not be disposed of in the watercourse, or anywhere where it could be reintroduced into the watercourse.</u>

Restoration of the channel to as near preconstruction conditions as possible will minimize the potential for long-term effects resulting from alteration of the channel morphology and composition of the bed material.

11. When marine equipment such as floating dredges is used, the appropriate auxiliary equipment should be available for the removal of spoils to the designated disposal site.

Unless the dredge is capable of pumping the spoils to shore (e.g. hydraulic pipeline cutterhead suction dredge), transport of the dredge spoils will require the use of barges/scows and appropriate pump-out equipment at the disposal site.

In soft material it is sometimes possible to open a pipeline trench by means of a high pressure jetting device. This approach, however, is strongly discouraged, since it forces large quantities of sediment into the water column at considerable distances from the crossing site. This is especially undesirable in regions where contaminated sediments may occur, or where high suspended sediment and turbidity levels are intolerable.

For most inland watercourses, all trench spoils must be placed onshore unless the appropriate agency (e.g. MOE, MNR) approves their instream disposal. In major rivers (e.g. Ottawa, St. Clair) and lakes, the suitability of spoils for open water disposal will be determined by MOE's guidelines (MOE 1976).

12. Measures should be undertaken to ensure that the discharge of hydrostatic test water does not adversely affect water quality or cause scouring of the channel.

Use of gravel pads, strawbales, and discharge into dense vegetative ground cover are among those measures commonly employed to protect the stream channel from the impact of high velocity water in the vicinity of the test water outfall. In addition, aquatic biota should be protected from entrainment at the test water intake.

Rust and a variety of other materials may be removed during pipeline cleaning and it is necessary that all such material be collected and transported to an acceptable disposal site (if disposal is desired at other than an MOE approved site a rigorous analysis of the material will be required). The concentration of chemicals used in relation to pipeline cleaning should not be toxic to aquatic biota. MOE or other appropriate regulatory agencies (e.g. MNR) should be consulted on the use of such chemicals.

13. Stream diversions should only be used during watercourse crossings when no feasible alternatives exist.

Such operations may result in major erosional damage to the new channel and the subsequent introduction of sediment into the watercourse at the downstream point of confluence.

The use of diversions for dry crossings must be compared to other dry crossing techniques and consideration should be given to the approach which will result in the least degradation to the physical environment and water quality.

Additional problems associated with diversions relate to the disposal and stabilization of the large quantities of spoil from the new channel, and the post-construction restoration of the diversion channel.

Where approval for a diversion is given, MOE's guidelines for stream diversion should be followed (MOE 1976).

14. The use of rip-rap for stabilization of streambanks should provide protection from the channel bed to the high water line in order to prevent subsequent bank failure due to undercutting or washing out.

Field investigations have shown that although random dumping of rip-rap material over a streambank has, in many cases, protected the above-water region of the bank, the earth fill below the rip-rap is unprotected and eventually washes out, causing the entire bank to slump. This can lead to accelerated erosion and in some instances, quiescent embayments of poor water quality.

In order to avoid these problems rip-rap should be carefully placed on a correctly graded slope from the stream bed up to the high water-line.

15. Plugs should be left in place between the instream trench and the onshore main trench leading to the instream trench until immediately prior to the pipe laying operation to prevent erosional losses from the main trench gaining access to the watercourse.

Once the plugs are removed, a channelized access is provided to the watercourse and, depending upon the slope and soil type, a considerable amount of material may be eroded from the onshore trench and introduced into the watercourse.

A plug of approximately five metres in length (from the water's edge toward the top of the bank) will minimize the input of sediment to the watercourse.

16. Antiseep collars (breakers) should be used to impede subsurface drainage and thus reduce the washing out of subsurface material by piping.

In regions with long or steep slopes "internal erosion" caused by subsurface drainage around a newly placed pipe can be a serious problem leading to differential settling of the pipe and backfill. Impermeable barriers at appropriate intervals reduce the erosive force of the subsurface flow and encourage infiltration.

17. Aquatic vegetation which is removed prior to or during the trenching operation should be contained and adequately disposed of on land.

Vegetation which is allowed to drift downstream may adversely affect downstream users as the result of flow obstruction or choking of water intakes. Decaying vegetation may also cause odour and aesthetic problems.

18. Construction methods involving blasting operations should be approved in advance by all relevant agencies and parties (e.g. MOE, MNR, Conservation Authority, land owner).

Blasting operations within a watercourse has the potential to cause serious impacts on aquatic biota and watercourse users. Advance approval ensures that operations can be planned to cause minimal disruption.

19. Construction timing should be determined through consultation with MOE and MNR so as to avoid interference with the migration and spawning of particular fish species.

Disruption of spawning beds and impedance of migration, through degradation of water quality and the presence of instream machinery, may have serious consequences on the fisheries resource potential of a stream.

3.2 The Environmental Study Report

It is usual for the OEB to require that a proponent prepare an "Environmental Study Report" (ESR) which will be circulated to concerned agencies for review. That portion of the report covering watercourse crossings for a given project must include: an assessment of the existing environmental conditions, the rationale for selection of the proposed crossing site, an outline of mitigative measures, a description of the proposed undertaking, and an indication of the post-construction stabilization and restoration techniques that are to be employed.

Prior to the submission of the environmental study report, the proponent must ascertain the sensitivity of the watercourse involved since this will dictate the level of detail required. This will best be achieved through "pre-submission" of preliminary environmental assessment information for review by local Ministry staff and other concerned agencies. Such information would include photographs of the selected reach (e.g. 300 m upstream and downstream of the proposed crossing), a detailed map showing the location of the crossing, and a listing of native fish species in the river.

If there is any indication that water use will be adversely affected by the short-term and/or long-term impacts (see sections 2.2 and 2.3), then the watercourse may be designated "sensitive" and the type of approach outlined in section 3.2.1 should be used to document baseline conditions and plan construction procedures. The procedure for those streams which are not designated "sensitive" is outlined in section 3.2.2.

NOTE: Sections 3.2.1 and 3.2.2 are guidelines only and should not be interpreted as exhaustive listings of ESR requirements.

3.2.1 ESR Outline for Sensitive Watercourses

Existing Environment

A thorough description of the existing environment (pre-construction conditions) will be of value to both the proponent and reviewers. First, it provides interested parties with the quantitative data necessary for evaluating the degree of watercourse sensitivity and hence the rationale for the proposed crossing techniques. Second, it supplies the proponent with a set of environmental parameters to guide post-construction restoration.

This section of the submission should include the following information.

1. A discussion of topography and land use for the flood plain and valley walls will permit the estimation of the erosion potential over the right-of-way, as well as aiding in the selection of the most appropriate construction and site restoration methods.

2. Information regarding instream and nearstream subsurface conditions will be of great importance in the assessment of erosion potential and hence construction and restoration approaches. Such data as depth of water table, depth of bedrock, and overburden composition and structure will be necessary.

3. Data corresponding to the expected time of construction on such parameters as bankfull width and mean depth should be included in addition to low flow data such as stage, width, mean depth, mean velocity and discharge. These will allow the construction of channel cross section profiles and an assessment of the potential range of flows to be expected during the period of construction.

4. The presentation of grain size data for the stream bed material, and the sinking of bed cores to the proposed trench depth will provide a thorough knowledge of substrate conditions and will ensure that instream work is well planned and rapidly executed (i.e. no delays as the result of unanticipated subsurface conditions).

5. Wherever possible, water quality data indicating the usual annual range of parameters should be included as a means of assessing the relative impact of the crossing operation upon the watercourse.

6. Fish populations and spawning areas should be defined to assist in the selection of the most appropriate mitigative measures.

Proposed Undertaking

This section should provide a detailed description of the proposed undertaking and should include the type of information presented below.

1. The type of crossing should be indicated (i.e. wet or dry) and justified in terms of the baseline data provided in the description of the existing environment. This discussion should also provide a general indication of the type of equipment to be used.

2. Details of construction techniques and restoration scheduling should be provided for all instream and flood plain activities (see Section 1.).

3. Plan and cross sections of the watercourse and approaches should be provided indicating: the depth and alignment of pipe; the location of plugs, spoil piles and backfill stockpiles; and the placement of any temporary instream structures.

4. Mitigative measures and techniques to be used during construction should be highlighted. These will include: types of structures for the containment of spoils and backfill; backfill material specifications; procedures for land clearing and stockpiling; and equipment crossing restrictions.

5. Procedures for post-construction stabilization and restoration should be supplied. This will include a description of the various channel and flood plain stabilization measures with supplementary plan and cross sections showing their exact location and extent. A strategy for long-term restoration of the site to as near pre-construction conditions as possible should also be provided (i.e. in addition to any interim measures).

6. In some instances monitoring of construction and/or long-term impacts may be appropriate (see Section 4.0) in which case details of the program should be provided. In all cases contingency plans and emergency procedures for events such as spills, precipitation of unusual intensity and/or duration, or unexpected work stoppages should be provided.

3.2.2 ESR Outline for Other Watercourses (Non-Sensitive)

For those watercourses which have not been designated sensitive the same approach should be used (i.e. descriptions of the existing environment and proposed undertaking) but the level of detail contained in the submission need not be as high. The proponent should include the following minimum requirements:

(a) a brief description of the watercourse and bed material characteristics;

(b) an outline of crossing techniques, equipment and scheduling; and

(c) a site restoration plan.

This last item will be of the most significance since even in a watercourse where no user concerns have been identified prior to construction there is the potential for subsequent concerns as the result of long term impacts.

3.3 Contract Specifications and Environmental Protection

EXPERIENCE WITH PIPELINE CONSTRUCTION IN ONTARIO HAS SHOWN THAT THE INCLUSION OF ADEQUATE PROVISIONS FOR ENVIRONMENTAL PROTECTION IN THE ENVIRONMENTAL DOCUMENT SUBMITTED FOR REVIEW, DOES NOT ENSURE THEIR IMPLEMENTATION.

Frequently the practices carried out in the field vary greatly from the recommendations put forward in the assessment document. This places reviewers in the awkward situation of having approved a document on the basis of protective measures which are not implemented in the field.

The contract document appears to be the most feasible mechanism for ensuring compliance by the contractor with the conditions agreed to by the proponent and review agencies (through the appropriate energy board). The contract should reasonably reflect the requirements of the environmental document and to this end the contractor should be required to provide assurances that the environmental control measures are fully understood prior to finalization of the contract document. This could be achieved through submission of an implementation procedure document.

In addition, the contract should include provisions which would allow a duly appointed inspector to issue on-site written notices of violation for those instances when the contractor fails to comply with contractual obligations.

Finally, the contractor must provide assurance that all local, provincial, and federal regulations regarding watercourse pollution will be adhered to. Appropriate regulations must be cited and the procedure for compliance must be outlined.

4. MONITORING OF PIPELINE CROSSING IMPACTS

Although implementation of a monitoring programme is not required in all cases (at the discretion of the regional director of MOE), the sensitivity of a particular watercourse may require that an appropriate monitoring programme be carried out.

The results of any such monitoring programme will be of benefit in that they will enable the accumulation of a representative data base on various crossing techniques and mitigative measures for a variety of watercourse types. This information will assist regulatory agencies such as MOE, and MNR in evaluating impacts and control techniques and will allow the development of improved guidelines and recommendations for impact mitigation.

4.1 Monitoring Objectives

The fundamental purpose of a monitoring programme is to provide the data necessary for a quantitative assessment of the impacts of a watercourse crossing operation upon the watercourse environment. It should be undertaken with the intention of answering the following general questions:

1. How much sediment is being introduced into the system as a result of the crossing operation, and what is the effect on other water quality parameters?

2. What is the downstream extent of elevated sediment concentrations and related parameters, and where is the material being deposited?

3. How do sediment concentrations and related parameters vary over the construction phase, and are there any long-term changes from pre-construction levels?

4. What are the short-term and long-term effects on aquatic biota, and which communities are affected?

4.2 Data Analysis and Presentation

The specific data requirements for a study will depend on the methods of analysis and presentation which are to be used. It is, therefore, important that this information be included in a monitoring proposal which should be available for review by the respective regulatory agencies prior to implementation of the programme.

APPENDIX I

TURBIDITY AND SUSPENDED SOLIDS

Discussion of instream sediment load requires that the terms "turbidity" and "suspended solids" be defined since they are not synonymous.

"Turbidity" is a measure of the ability of water to transmit light. It is an optical property and depends upon the light scattering characteristics of material suspended in the water. Similar concentrations of various suspended particles (e.g. micro-organisms, organic debris, mineral particulates) will result in differing turbidity readings and it is, therefore, not generally feasible to develop a reliable correlation between turbidity and quantity of suspended solids. Photo-electric turbidity readings are commonly recorded in Jackson Turbidity Units (JTU), Formazin Turbidity Units (FTU), Turbidity Units (TU), and Nephelometric Turbidity Units (NTU) by means of a turbidity meter.

"Suspended solids" are reported either as sediment mass per volume water, or as sediment mass per mass water. The standard units are milligrams per litre ($mg\ L^{-1}$), and parts per million (ppm) respectively.

APPENDIX II

DRY CROSSINGS

If the use of a dry crossing is deemed necessary thorough investigations must be carried out to ensure that the technique will work safely and effectively. The following factors should be considered:

- erratic flow conditions (e.g. periodic large volume release from upstream reservoirs);

- anticipated river conditions during periods of high precipitation;

- the availability of a discharge area for water pumped during instream and nearstream trench dewatering and appropriate protection from erosion/scour;

- the influence of the local ground water conditions on the dewatering operation;

- provision for the removal and proper disposal of accumulated sediment from the sediment barriers; and

- the consideration of techniques for the proper placement and removal of devices so as to minimize disturbance to the stream bed.

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EVALUATING CONSTRUCTION ACTIVITIES IMPACTING ON WATER RESOURCES: PART II

GUIDELINES FOR CONSTRUCTION OF HIGHWAYS AND BRIDGES

March, 1984

Ontario
Ministry of the Environment

The Honourable
Morley Kells
Minister

Dr. Allan E. Dyer
Deputy Minister

EVALUATING CONSTRUCTION ACTIVITIES IMPACTING ON WATER RESOURCES: PART II

GUIDELINES

FOR

CONSTRUCTION OF

HIGHWAYS AND BRIDGES

March, 1984

Prepared by:

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FOREWORD

In 1976 the Ontario Ministry of the Environment (MOE) published the handbook Evaluating Construction Activities Impacting on Water Resources to be used in the assessment of the environmental impacts of construction activities. At that time it was indicated that the handbook would be revised as further information was accumulated, and the considerable experience gained since 1976 now warrants such a revision in order to better reflect current knowledge. These guidelines for the construction of highways and bridges form the second of five parts in an updated set of handbooks designed to replace the 1976 handbook. The other parts, each to be published as a separate volume, deal with the construction of pipelines crossing watercourses (Part I 1983); dredging and spoils disposal (Part III 1984); marine construction (Part IV 1983); and small scale construction projects (Part V 1983);.

Most highway and bridge projects in the Province of Ontario are undertaken by the public sector and are, therefore, subject to the Environmental Assessment Act. Proponents of such projects are required to prepare an Environmental Assessment (EA) for review by concerned agencies prior to a decision by the Minister of the Environment regarding approval. From a water resources perspective, good construction practice requires that every effort be made to preserve the physical and biological integrity of Ontario's waterbodies in accordance with Provincial goals to preserve and enhance ground and surface water quality and quantity (Ontario Ministry of the Environment 1978).

This document has been compiled to aid proponents and reviewers by providing a basic information package of water resources concerns for use in the impact assessment process. The aim is to provide assistance in both anticipating potential impacts and in planning adequate mitigative measures. Clearly, the type and scale of each project, in conjunction with site specific conditions, will determine which of the wide range of potential impacts will require specific attention. Similarly, the technical aspects of mitigative measures (and associated monitoring) will vary according to individual project circumstances.

Accordingly, the first chapter presents a general range of potential adverse impacts on the water environment associated with highway and bridge construction projects and is followed by a chapter containing general recommendations for their mitigation. The final chapter provides suggestions for meeting water resources content requirements during EA preparation as a means of streamlining the review process.

Although it is not possible to document every potential problem associated with highway and bridge projects in a handbook such as this, it is hoped that most major concerns have been covered. The key to successful application of the recommendations outlined in this handbook is a precise understanding of their rationale on the part of the proponent and its contractor(s). Proponents are encouraged to consult with local MOE offices early in the planning and design process so that potential concerns are raised at a stage when they can be most readily addressed.

I POTENTIAL IMPACTS OF HIGHWAY AND BRIDGE CONSTRUCTION PROJECTS ON THE WATER ENVIRONMENT

1. INTRODUCTION

The construction of highway and bridge projects results in a range of effects upon the water environment (i.e. physical and chemical changes in the stream system) which can be evaluated and expressed as an impact (i.e. the result of the effect on the stream biota and other beneficial uses). This distinction between an effect and an impact can be illustrated by the case when introduction of construction related sediment into a watercourse occurs. One effect of this activity is the temporary creation of turbid water. This effect may result in an adverse impact on fish.

Depending on site specific conditions and the type of project, any of a wide range of effects may occur creating the potential for adverse impacts of varying magnitude. In general, impacts on water resources can be described as short-term or long-term, depending on whether they are associated with the construction, or post-construction phase of a project.

The initial sections of this chapter outline various short-term and long-term effects on the physical/chemical water environment which may occur due to highway and bridge construction and operation. This is followed by a discussion of the resulting potential impacts upon aquatic biota, and other beneficial uses.

2. SHORT-TERM EFFECTS ON THE ABIOTIC WATER ENVIRONMENT

Effects related to the construction phase are the most easily observed and frequently can be directly attributed to specific activities. The most common effects are summarized below.

2.1 Erosion and Sedimentation

The major impact on the water environment associated with the construction phase is the input of sediment as a result of increased land surface erosion. The absence of protective vegetative cover during clearing, grading, blasting and trenching operations, combined with the continual movement of heavy equipment decreases the infiltration capacity of the soil and renders the surface highly susceptible to erosion by surface runoff. As a result construction has been demonstrated to yield the highest erosion rates of any land use activity (Canter 1977).

Once eroded material has been washed into a watercourse it may, depending on the particle size and watercourse flow, settle to form a bed deposit, or become entrained as bedload and/or suspended load. In most cases a combination of the three occurs.

2.2 Degradation of Ground and Surface Water Quality

The most direct cause of surface water quality degradation is in or near stream construction activity. However, water quality within and adjacent to construction sites will also be affected by the input of various pollutants (e.g. metals, oil and grease, asphalts, calcium chloride, etc. from construction machinery, access roads, etc.) via surface runoff. Once in the watercourse suspended particles increase turbidity and provide a medium for the transport of adsorbed contaminants.

Depending upon the drainage characteristics of the site and surrounding area, pollutants may be transported considerable distances and water quality may be impaired at points well removed from the original site.

Ground water quality may also be affected temporarily due to infiltration of contaminated surface water.

2.3 Disruption of Ground and Surface Water Quantity

Such activities as the dewatering of trenches, cut and fill operations, blasting, and the reduction of infiltration due to surface compaction, can disrupt the pattern of ground and surface water flow by altering ground water levels.

Flow diversion for instream work may substantially alter the pattern of streamflow and result in such negative effects as increased scour (in-channel erosion) within the diversion, increased sedimentation downstream, or cessation of flow during low flow periods.

2.4 Damage to Watercourse Bed and Banks

Blasting operations and the operation of heavy equipment on the bed and banks of watercourses can cause significant changes in channel morphology. This will alter the watercourse flow pattern, and may result in effects such as scour, increased concentrations of suspended solids, and blanketing of the channel bed.

3. LONG-TERM EFFECTS ON THE ABIOTIC WATER ENVIRONMENT

Effects occurring during the post-construction phase of a project are much more difficult to predict and explain. Such effects tend to be indirect and may occur gradually over a prolonged period. The most obvious effects are summarized below.

3.1 Channel Modification

Channel modification is frequently necessitated in those cases where projects cross or infringe on a watercourse (i.e. protection from overbank flows and stabilization of banks). This is usually achieved by some combination of: straightening, widening, deepening, clearing, lining, bank reconstruction, modification of grade, rerouting of existing drainageways, and construction of artificial drainage systems.

Natural watercourses represent a "quasi-equilibrium" of sediment and water inputs and outputs. Since channel modification has the potential to disrupt this equilibrium, resulting in both local and basin wide effects, it is of fundamental importance that adequate consideration be given to potentially adverse environmental effects.

Alteration of a watercourse regime may occur as the result of local changes in bed/bank morphology and composition (i.e. altered depth, width, gradient, size of bed material). Morphological changes often result in altered flow patterns which disrupt the local scour and fill (short-term, in-channel erosion and deposition) equilibrium. The interdependent nature of channel morphology, watercourse flow patterns, and bed material composition can, therefore, result in the migration of local changes up and down the stream system.

3.2 Increased Surface Runoff

Highway and bridge construction results in the replacement of "natural" surfaces by highly impervious paved surfaces. This will reduce infiltration, lag time, and subsurface flow, while the total

volume of runoff increases (i.e. greater volumes of water will flow over the surface at higher velocities reaching a watercourse in less time compared to preconstruction conditions). In general, post-construction peak flows tend to be increased and base flows tend to be reduced. The most significant consequence of this altered range of discharges is increased channel activity. Guy (1970) has noted that while erosion of the land surface is the major problem during construction, channel erosion predominates during the subsequent stabilization period.

3.3 Degradation of Surface Water Quality

Water quality can be impaired as a result of any reduced ground water component of stream flow and a corresponding increase in the contribution of surface runoff. Reduced low flows mean that the assimilative and flushing capacity of a stream is reduced, while the increased surface runoff will transport contaminants (e.g. oil and grease, deicing compounds, etc.) directly into the watercourse without the benefit of subsurface filtering (i.e. under natural conditions contaminants may be adsorbed and particulates retained during infiltration).

3.4 Disruption of Ground Water Quality and Quantity

A completed project has the potential to alter ground water conditions, locally and regionally, by changing the slope and soil composition of an area and hence the gravitational and capillary forces which govern subsurface flow. Outflows from excavations can result in the permanent lowering of ground water levels. The quality of ground water can be impaired by the percolation of contaminated surface runoff down to aquifers.

4. POTENTIAL IMPACTS ON AQUATIC BIOTA

Potential impacts on aquatic biota may result from both short and long term effects on the water environment. Interference with any part of the stream ecosystem structure has the potential to adversely affect the entire system.

For the purposes of the following discussion the complex and interrelated components of the ecosystem have been classified as primary productivity, benthic organisms, and fish.

4.1 Primary Productivity

The photosynthetic production of organic matter by the lower members of the aquatic food web (autotrophs) is referred to as primary productivity. It may be adversely affected by short-term increases in levels of suspended solids and associated contaminants, first as a result of light attenuation, and second as the result of direct exposure to toxic substances.

Long term impacts usually relate to modification of channel morphology, flow characteristics, and bed material composition. The increased peak flows, reduced base flows, and loss of in-channel morphological variation (i.e. pools and riffles) which accompany stream modification may preclude recolonization by species present before construction. Since primary productivity represents a nutrient source for other components of the stream ecosystem this impact may be far reaching.

4.2 Benthic Organisms

The survival of benthic organisms depends upon the preservation of the watercourse substrate as suitable habitat. The blanketing of the channel bed with contaminated sediment which may accompany near-stream construction activity, and the damage which results from in-stream work, both act as severe stresses to the benthic community. Organisms may either be destroyed (i.e. smothered or exposed to toxic compounds) or they may drift downstream (Hynes

1973) and since they form a vital link in the aquatic food chain dependent predators will be forced to abandon any regions thus affected.

Long term impacts can also be expected to occur as the result of alterations to the watercourse regime (i.e. increased peak flows, reduced base flows, channel modification effects). The disruption of the pre-construction scour and fill equilibrium, loss of in-channel morphological variation, and changes in bed material composition will all result in loss of suitable habitat.

In addition, the removal of riparian vegetation (which frequently accompanies channelization) will reduce the amount of leaf litter which enters the system. Since, in small streams, this represents the major source of organic matter utilized by the stream community (Cummins and Spengler 1978), benthic organisms may also encounter a critical nutrient shortage.

4.3 Fish

The increased turbidity and impaired water quality associated with the construction phase of projects will adversely affect local fish populations, while in-stream work will have the additional effect of impeding migratory passage.

Fish which rely on sight for feeding and the detection of predators will experience a reduction in their reactive distance as a result of high turbidity levels (Illinois EPA 1979). High suspended sediment concentrations may also disrupt the respiratory mechanism of fish through clogging or abrasion of the gills. Although many species of adult fish are able to withstand this, by exuding a protective mucous, their survival is still jeopardized by the associated depletion of metabolic reserves at a time when turbidity inhibits the detection of food (Illinois EPA 1979).

Sediment accumulation in spawning areas can also affect the hatching of eggs by clogging substrate interstices thereby interfering with the normal exchange of water which replenishes the oxygen supply and removes accumulated wastes. It may also pose a physical obstruction to emerging fry.

The loss of reproductive capacity through physiological stress, loss of spawning beds, and destruction of fry may result in a more significant impact than short-term abrasion and clogging (Illinois EPA 1979).

Long-term disruption of pre-construction habitat may occur in several ways. For example, the removal of riparian vegetation causes a loss of shade which can increase the magnitude of water temperature fluctuations thereby affecting dissolved oxygen levels and eliminating the cold water fishery potential of certain streams. The loss of in-channel shelter, long-term damage to spawning beds, decreased low flows, and impaired water quality may also have a severe impact on fish populations.

In addition to these direct impacts, the loss of food resulting from impacts on primary productivity and benthic organisms will also tend to inhibit post-construction re-colonization by former species.

5. POTENTIAL IMPACTS ON OTHER BENEFICIAL USES

In addition to causing negative impacts on the watercourse ecosystem, the short and long term effects of construction projects can have other adverse impacts. These are summarized below.

5.1 Impaired Water Supply

Short-term impacts on recreational and drinking water supplies may occur as the result of construction related increases in turbidity and contaminant levels, or disruption of ground or surface water flow.

Long-term impacts will relate to post-construction effects on the quality and quantity of ground and surface water. Contamination and disruption of ground and surface water supplies will adversely affect water users, both local and regional.

5.2 Flow Obstruction and Increased Downstream Flood Hazard

Flow obstruction frequently results from construction related accumulations of sediment and debris. The increased peak flows associated with the post-construction phase of the project will result in an increased downstream flood risk which may be exacerbated by residual flow obstructions.

5.3 Structural Damage

Construction related damage to watercourse banks (e.g. operation of heavy equipment, removal of vegetation, subsidence from dewatering) can increase their susceptibility to subsequent erosional damage and slumping, as can the increased channel activity associated with alterations in the local hydrological regime. This may endanger such nearby structures as buildings and roads, and can lead to the failure of in-channel structures such as bridges and culverts.

5.4 Impaired Recreation

Both construction and post-construction effects have the potential to disrupt downstream recreation. Direct use of a watercourse for activities such as swimming or fishing will be curtailed by the short-term effects on water quality (see Section 2) and by loss of access. Indirect uses such as adjacent parks and trails will suffer from such long-term effects as the loss of aesthetic value due to depleted low flows, bank failures, and the installation of unsightly stabilization measures (e.g. gabion baskets, concrete channel).

II RECOMMENDATIONS FOR HIGHWAY AND BRIDGE CONSTRUCTION

1. INTRODUCTION

The construction of highways and bridges has the potential for a wide range of impacts on the water environment (as outlined in Chapter I). The potential significance of this type of project is illustrated by the fact that construction of a typical four-lane highway exposes roughly 50 x 10^3 m^2 of ground per kilometre (20 acres per mile), of which approximately half is eventually covered by the paved surface and shoulders (Wolman and Schick 1967).

Chapter II briefly outlines various highway and bridge construction operations as a means of classifying a list of recommendations for construction of highways and bridges with minimal short and long-term impacts on the water environment.

2. OVERVIEW OF HIGHWAY AND BRIDGE CONSTRUCTION OPERATIONS

Details of construction operations will depend upon the size of the project, site specific conditions, and the contractor. For the purposes of these guidelines, however, a series of general, interdependent operations have been summarized below.

GENERAL SUMMARY OF HIGHWAY AND BRIDGE CONSTRUCTION OPERATIONS

OPERATION	DESCRIPTION
Clearing and Grubbing	A variety of equipment is used to remove trees and stumps, and other vegetation from the right-of-way (RoW).
Grading	Heavy equipment and/or explosives are used to "cut" and "fill" original topography to the grades specified in contract drawings. "Borrow" material may be required in some cases, while in others disposal of surplus material may be necessary.
Drainage	Excavation of temporary and permanent drainage ditches and stream diversions is undertaken, and culverts and storm sewers are installed.
Preparation of the Road Bed	Heavy equipment is used to compact the surface, and a layer of granular material is installed.
Surfacing	Concrete and/or asphalt paving is installed.
Bridges	Embankments are constructed, foundations are installed and footings, abutments and piers are constructed to support the superstructure and deck.

3. RECOMMENDATIONS

Generally speaking, the mitigation of construction-related impacts can be achieved through a combination of good construction practices and various site specific "control" methods. Mitigation of long-term impacts, on the other hand, is usually best addressed through a combination of careful project design and site restoration.

3.1 Mitigation of Potential Short-Term Impacts

The following recommendations for mitigation of construction-related impacts are presented according to the general sequence of operations as indicated previously.

3.1.1 Clearing and Grubbing

(1) VEGETATIVE COVER SHOULD BE PRESERVED FOR AS LONG AS POSSIBLE.

Soil can be protected against erosion by preserving easily removed ground cover (e.g. brush, shrubs, etc.) until grading operations are ready to commence.

(2) ALL ACCUMULATED DEBRIS AND SOIL RESULTING FROM CLEARING AND GRUBBING SHOULD BE LOCATED AWAY FROM WATERCOURSES AND TEMPORARILY STORED OR DISPOSED OF IN A MANNER ACCEPTABLE TO ADJACENT PROPERTY OWNERS AND/OR RELEVANT GOVERNMENT AGENCIES (e.g. Ontario Ministry of the Environment (MOE), Ontario Ministry of Natural Resources (MNR), local Conservation Authority).

Locating stockpiles of cleared material away from watercourses will prevent the degradation of water quality by sediment and organic debris. Permission of property owners and government agencies regarding method and location for disposal of such material will ensure adequate consideration of site specific concerns.

(3) REMOVAL OF RIPARIAN VEGETATON SHOULD BE MINIMIZED.

Riparian vegetation provides a buffer between areas under construction and watercourses which can help protect against degradation of water quality by contaminated runoff (i.e. through filtration of overland flow). It also forms a valuable nutrient and habitat component of the stream ecosystem.

(4) IN REGIONS WHERE POTENTIAL IMPACTS ON FISHERIES EXIST, CONTACT SHOULD BE MADE WITH APPROPRIATE GOVERNMENT AGENCIES (e.g. MOE, MNR) PRIOR TO THE COMMENCEMENT OF ANY CONSTRUCTION ACTIVITY.

The fishery potential of a stream will play a fundamental role in determining construction techniques and timing as well as the design of instream structures. For this reason, contact should be made with MOE and MNR early in the planning and design stage.

3.1.2 Grading

(1) NEWLY GRADED SLOPES SHOULD HAVE ADEQUATE EROSION CONTROL MEASURES INSTALLED AS SOON AS POSSIBLE (e.g. berms, rip-rap, aggregate cover, seeding mulching, sodding, vegetation plugs, etc.).

Any recently excavated or filled area will be highly susceptible to erosion until it is stabilized. Wherever possible stabilization should be part of the grading operation.

(2) BLASTING SHOULD BE UNDERTAKEN IN A MANNER DESIGNED TO MINIMIZE WATER QUALITY AND QUANTITY IMPACTS ON LOCAL WELLS AND WATERCOURSES. MONITORING OF POTENTIALLY AFFECTED WELLS SHOULD BEGIN PRIOR TO BLASTING.

A careful estimation of the potential impacts on local wells and streamflow incorporating all necessary hydrogeological and water quality data should accompany all proposals to excavate by means of blasting. Suitable precautions can then be taken to prevent damage to channel morphology and subsurface soil structure.

3.1.3 Drainage

(1) THE CONSTRUCTION OF ALL TEMPORARY AND PERMANENT DRAINAGE DITCHES, CULVERTS AND SEWERS SHOULD BE COMPLETED AS RAPIDLY AS POSSIBLE. THESE ACTIVITIES SHOULD INCORPORATE EROSION AND SEDIMENT CONTROL MEASURES SUFFICIENT TO ENSURE THAT OFF SITE IMPACTS ARE MINIMIZED.

Local and downstream impacts on surface water can be minimized by planning construction schedules so that all the necessary materials and equipment to complete the job are on site prior to excavation, and by ensuring that the installation of erosion and sediment control measures is incorporated into the construction process. Rapid completion and restoration of temporary drainageways will also help minimize disruptions of ground water flow resulting from "french drain" effects (i.e. diversion of ground water flow).

(2) DEWATERING OPERATIONS SHOULD INCORPORATE MEASURES TO MINIMIZE IMPACTS ON GROUND AND SURFACE WATER USERS. OUTFALLS SHOULD BE LOCATED AND PROTECTED SO AS TO PREVENT ANY EROSIONAL DAMAGE (e.g. gravel or grass "splash pad"). ALL WATER USERS WHOSE SUPPLIES ARE INTERRUPTED SHALL BE PROVIDED AN ALTERNATE SOURCE (as outlined in the Ontario Water Resources Act).

The impact of any temporary disruption in ground and surface water supply by construction related dewatering operations can be reduced through (a) advance notification of potentially affected users and provision of alternate supply where needed, (b) rapid completion of activities, and (c) the application of effective erosion control at outfalls. Extraction of more than 50 m^3 per day will require a "Permit To Take Water" from MOE.

(3) THE CONSTRUCTION OF ANY NEW DRAINAGEWAY SHOULD BE UNDERTAKEN BY MEANS OF DRY CONSTRUCTION. THE NEW CHANNEL SHOULD BE COMPLETED AND ADEQUATELY ARMOURED WHEREVER NECESSARY PRIOR TO THE DIVERSION OF FLOW FROM EXISTING DRAINAGE NETWORK.

Channel excavation not utilizing dry construction can result in massive sedimentation, slumping of banks, and other related impacts.

3.1.4 Preparation of the Road Bed

(1) ANY RUNOFF FROM AREAS BEING COMPACTED SHOULD BE PREVENTED FROM DIRECTLY ENTERING WATERCOURSES.

Surface compaction reduces soil infiltration capacity and encourages sediment laden overland flow. This will require the application of adequate sediment control measures (e.g. impoundment, filtering) in order to minimize the input of sediment into watercourses.

3.1.5 Surfacing

(1) PRECAUTIONS SHOULD BE TAKEN TO ENSURE THAT PAVEMENT CONSTRUCTION DOES NOT RESULT IN WATERCOURSE CONTAMINATION BY SUCH MATERIALS AS LIME, CEMENT, OIL AND GREASE, ASPHALT, ETC.

Contaminated runoff can result in significant local and downstream impacts and should, therefore, be restricted from direct entry into watercourses.

3.1.6 Bridges

(1) THE APPROPRIATE AGENCIES (e.g. MCE, MNR, Conservation Authority) SHOULD BE CONTACTED TO ENSURE THAT ALL INSTREAM AND NEARSTREAM ACTIVITY IS PLANNED AND CARRIED OUT SO AS TO CAUSE MINIMAL DISTURBANCE TO FISH, RECREATION, AND ANY OTHER LOCAL USES.

Depending upon the site specific circumstances a variety of concerns will necessitate such "good housekeeping" precautions as: acceptable disposal and stabilization of excavated,

erodible material; use of protective dykes or cofferdams; maintenance of adeqate channel capacity; erosion protection; bank stabilization; and designation of acceptable refuelling areas.

(2) INSTREAM AND NEARSTREAM WORK SHOULD BE COMPLETED AS RAPIDLY AS POSSIBLE DURING THE LOW STREAMFLOW PERIOD.

Once such activity commences it is important that it be rapidly completed so as to confine the unavoidable adverse impacts on the watercourse to the season (usually summer) when the least amount of damage is likely to result.

(3) THE USE OF HEAVY EQUIPMENT ON STREAM BED OR BANKS SHOULD BE KEPT TO A MINIMUM. WHERE REPEATED CROSSINGS ARE REQUIRED THESE SHOULD BE CONFINED TO ONE LOCATION AND SHOULD EMPLOY AN ARMOURED FORD OR TEMPORARY BRIDGING.

Every effort should be made to prevent damage to watercourse bed and banks. This will reduce short-term impacts and simplify post-construction restoration.

(4) ALL NEAR-CHANNEL GRADING OPERATIONS (e.g. embankment construction) SHOULD INCORPORATE IMMEDIATE EROSION PROTECTION AND STABILIZATION.

Any fill deposited and graded adjacent to a watercourse has the potential to result in the input of large quantities of sediment. Every precaution should be taken to ensure that this does not occur.

3.1.7 Monitoring and Maintenance

(1) ALL MITIGATIVE MEASURES SHOULD BE MONITORED REGULARLY TO ENSURE CONTINUED EFFECTIVENESS AND ALL NECESSARY MAINTENANCE SHOULD BE UNDERTAKEN IMMEDIATELY. RESULTS OF MONITORING SHOULD BE AVAILABLE FOR REVIEW BY MOE AND/OR OTHER CONCERNED AGENCIES.

The installation of various mitigative measures cannot be expected to provide adequate protection unless complemented by regular inspection and maintenance by the proponent. Contingency measures should be available in case of sub-standard performance or failure of existing measures.

3.2 Mitigation of Potential Long-Term Impacts

The simplest and most effective means of minimizing long-term impacts is through careful consideration of potential impacts at the planning and design stage and through detailed attention to site restoration. The following recommendations represent general design and site restoration considerations for various aspects of highway and bridge construction.

3.2.1 Alignment

(1) WHERE FEASIBLE, RIGHT OF WAY ALIGNMENT SHOULD MINIMIZE THE NUMBER OF WATERCOURSE CROSSINGS AND MAXIMIZE THE DISTANCE FROM ACTIVE WELLS OR OTHER WATER USES.

The most effective way to minimize impacts on ground and surface water use is to avoid them altogether. The fewer the number of watercourse crossings and the greater the separation between the right of way, wells and other uses, the smaller the resulting impacts will usually be.

3.2.2 Grade

(1) DISRUPTION OF SUBSURFACE FLOW SHOULD BE MINIMIZED THROUGH THE USE OF APPROPRIATE FILL MATERIAL.

Although a certain amount of subsurface flow alteration is inevitable when changes in local topography and composition of surface material are made, this can be reduced through the selection of fill material which will minimize such alterations (e.g. creation of impermeable barriers, or "french drain" effects).

3.2.3 Drainage

(1) WATERCOURSE RECHANNELLING (i.e. permanent flow diversion) SHOULD BE AVOIDED WHEREVER POSSIBLE.

The rechannelling of a watercourse exemplifies extreme disruption of the natural system and its equilibrium and can result in severe post-construction impacts over a stabilization period of several years.

(2) ALL PERMANENT DIVERSION CHANNELS SHOULD BE PROTECTED, AND SHOULD INCORPORATE SUFFICIENT ENERGY DISSIPATION MEASURES AND/OR DOWNSTREAM EROSION PROTECTION TO PREVENT SCOUR AT (OR DOWNSTREAM FROM) THE POINTS OF CONFLUENCE WITH THE OLD CHANNEL.

If the project cannot avoid the need for permanent flow diversions the severity of the various impacts can be reduced through careful design.

(3) PERMANENT DRAINAGE DITCHES SHOULD BE DESIGNED TO MINIMIZE IMPACTS ON EXISTING WATERCOURSES AND GROUND WATER BY AVOIDING LARGE CUTS, INCORPORATING PROTECTION AGAINST SCOUR, AND AVOIDING UNPROTECTED DISCHARGES INTO NATURAL WATERCOURSES.

Water quality in ditches collecting surface runoff will be low. As a result it will be necessary to estimate whether local ground water resources require protection from contamination through infiltration of such water, or whether local surface water quality protection requires that it be prevented from directly entering natural water courses.

(4) CULVERT DESIGN SHOULD ENSURE MINIMAL UPSTREAM AND DOWNSTREAM EFFECTS BY INCORPORATING ADEQUATE INLET AND OUTLET EROSION PROTECTION WHEREVER NECESSARY, AND ENERGY DISSIPATION MEASURES TO PREVENT INCREASED DOWNSTREAM VELOCITIES. THE INVERT ELEVATION SHOULD PROVIDE A SUFFICIENT DEPTH OF WATER FOR THE PASSAGE OF FISH AT LOW FLOWS WHILE AVOIDING BACKWATER EFFECTS AT PEAK FLOWS. THE CULVERT DIAMETER SHOULD BE SIZED TO ACCOMMODATE ANTICIPATED DISCHARGE FLUCTUATIONS, INCLUDING THOSE RESULTING FROM ICE DAMMING OR OTHER BLOCKAGES.

Improperly sized and installed culverts can cause numerous post-construction impacts including nuisance conditions (e.g. stagnant ponding), structural damage (e.g. washing out of embankments), and disruption of habitat for aquatic organisms (e.g. barrier to fish migration).

3.2.4 Bridges

(1) BRIDGE DESIGN SHOULD MINIMIZE THE USE OF INSTREAM AND NEARSTREAM SUBSTRUCTURES AND SHOULD MEET THE APPROVAL OF ALL APPROPRIATE GOVERNMENT AGENCIES (e.g. MOE, MNR, Conservation Authority).

The extent of channel modifications, and hence potential impacts, can be reduced by locating structures as far from the watercourse as possible.

(2) CHANNEL MODIFICATION SHOULD CAUSE MINIMAL FLOW ALTERATION, INCORPORATE MEASURES FOR THE PROTECTION OF STREAM BANKS AND BED, AND ENSURE THAT FISH HABITAT IS NOT DREGRADED.

Where in-stream/near-stream structures or major channel modifications cannot be avoided the resulting impacts can be reduced through careful design and installation.

3.2.5 Site Restoration and Monitoring

(1) SITE RESTORATION TO AS NEAR PRECONSTRUCTION CONDITIONS AS POSSIBLE SHOULD BE INITIATED AND COMPLETED AS SOON AS POSSIBLE.

Delays between the completion of construction and site restoration can lead to short and long-term impacts (e.g. slumping of banks resulting from improper stabilization).

(2) WHERE NECESSARY INTERIM EROSION/SEDIMENT CONTROL MEASURES SHOULD BE INSTALLED UNTIL LONG-TERM PROTECTION CAN BE EFFECTIVELY IMPLEMENTED.

Where permanent restoration is not feasible (e.g. seeding outside growing season) the lack of interim measures can complicate long-term restoration by allowing further damage to occur.

(3) THE EFFECTIVENESS OF RESTORATION MEASURES (e.g. bank stabilization) SHOULD BE MONITORED BY THE PROPONENT AND NECESSARY MAINTENANCE SHOULD BE UNDERTAKEN PROMPTLY.

The mitigation of long-term impacts through careful site restoration can only succeed if adequately maintained. This should be considered normal project maintenance.

III MEETING WATER RESOURCES CONTENT REQUIREMENTS DURING ENVIRONMENTAL ASSESSMENT PREPARATION

1. INTRODUCTION

The following chapter outlines the general concerns and suggestions most commonly expressed during review, by MOE staff, of the water resources aspects of EA's. This guide will be especially useful as a time saving reference during the preparation and review of "pre-submission" type EA's.

The first section summarizes suggestions for presentation of information as a preamble to a discussion of baseline data requirements. Next, there is a brief consideration of project description and identification of potential impacts. A discussion regarding the assessment of impact magnitude follows, and the guide concludes with a discussion of content requirements concerning mitigative measures, construction practices, site restoration, and monitoring.

2. PRESENTATION OF INFORMATION

General suggestions regarding the water resources coverage in EA reports, which have been made on numerous occasions, can be summarized as follows:

(1) <u>All summary statements should be substantiated by valid references and/or data.</u>

All secondary sources (technical reports, correspondence, personal communications, etc.) should be identified as such and the appropriate reference(s) should be appended to the EA wherever possible.

An apparent conflict between two sources of information on a particular suject should not be suppressed. If one is favoured the reasons should be presented in a manner which allows the reader to assess the basis on which any judgements were made.

(2) <u>The results of all analyses should be verifiable.</u>

The presentation of numerical results and qualitative estimates cannot be considered adequate unless an outline of how they were obtained (i.e. data sources should be provided, calibration procedures explained, etc.) is appended. This will permit the reader to assess the accuracy of all interpretations or applications (e.g. tables, graphs, etc.).

3. BASELINE DATA REQUIREMENTS

Data on the water environment must provide the reader of the EA with a clear picture of the pre-construction conditions as they pertain to the quality and quantity of ground and surface water. Without this information it will not be possible to identify all the potential impacts of a proposal upon the water environment, and no determination of the magnitude of net impact will be obtainable.

General information describing the entire study area should precede more comprehensive site specific data regarding the preferred site/route. In some cases pertinent information may be derived from the "Biophysical Land Classification" program of Environment Canada.

3.1 Study Area Data

In most cases the study area overview should include information on the following:

- topography
- soil composition and drainage characteristics
- pleistocene stratigraphy
- land use
- ground and surface water resource locations and uses (well locations and depths, stream locations and sizes, recreational areas).

Experience has shown that an extremely useful method of satisfying these requirements is to prepare a series of maps at a scale capable of showing all permanent watercourses (in most cases the 1:20,000, 10 m contour topographic sheets ...available through the Ontario Basic Mapping Program of MNR... will be acceptable). If this approach is adopted these maps should be complemented by descriptive text.

3.2 Preferred Site/Route Data

Detailed, site specific water resources related data will be required on the preferred site/route (i.e. right-of-way, borrow sites, storage yards, etc.) as the basis for identification and estimation of the magnitude of potential impacts on the water environment. This will also assist in the interpretation of results from monitoring during construction and after project completion.

These data can be classified under the headings "surface water" and "ground water".

3.2.1 Surface Water Data

Site specific surface data should include:

a) precipitation records;
b) streamflow records;
c) flow duration and flood frequency curves (constructed from "a" and "b");
d) channel dimensions and geometry (bankfull and low flow width, depth, flow velocity, and slope, sinuosity);
e) local water quality (both upstream and downstream from "site");
f) local water usage (drinking, recreation, industrial, aquatic life);
g) bed material composition (grain size distribution, pool to riffle ratio);
h) near-stream/floodplain soil characteristics (composition, structure, drainage); and
i) local topography (slope, slope length).

This information will provide a good indication of the expected range of flows, the susceptibilty to surface damage and erosion, and the existing water quality and use. In addition to providing the basis for estimating the magnitude of impacts on the surface water, it will supply a description of pre-construction conditions which can be used as a goal for post-construction site restoration.

3.2.2 Ground Water Data

Site specific subsurface data should include:

a) pleistocene stratigraphy (thickness and composition of overburden, bedrock depth);
b) location and description of aquifers;
c) depth to water table levels (local well locations, seepage areas, borehole results);
d) ground water flow estimates (horizontal and vertical flows based on "a", "b" and "c"); and
e) water usage and quality.

This information should provide an understanding of existing ground water conditions upon which subsequent estimates of impact magnitude can be based, a goal for post-construction site restoration and baseline data for construction and post-construction monitoring.

Design details and mitigative measures will depend upon both surface and subsurface information (the importance of these data cannot be overemphasized).

The focus and presentation of this preferred site/route data will depend upon the nature of the proposed undertaking and the local environment. As with the study area data, however, maps which include topography and drainage can be used advantageously (in this case the suggested scale is 1:2000 with 1 m contours for topographic sheets). Site specific plans and cross sectional drawings are extremely valuable for such items as watercourse crossings or cut and fill activities.

4. DESCRIPTION OF THE PROPOSED UNDERTAKING AND IDENTIFICATION OF POTENTIAL IMPACTS

This section of an E.A., report should provide a level of detail sufficient to provide a clear understanding of project design, location, and types of construction activities, including sequence and timing. This information when evaluated in conjunction with the preferred site/route description will enable a comprehensive list of potential impacts on the water environment to be generated.

This list should incorporate specific aspects of both the project and the environment and does not, therefore, lend itself to a "standard checklist".

5. ESTIMATION OF IMPACT MAGNITUDE

Once the comprehensive list of potential impacts has been compiled an effort should be made to quantify them wherever possible. In many cases this will involve the application of appropriate models, the sophistication of which will depend upon the nature of the proposed undertaking and the sensitivity of the environment (as documented by the baseline data). Examples include estimation of the impacts resulting from: increased runoff (hence increased peak flows and depletion of base flows); increased sediment discharge; increased potential soil loss; increased stream velocity; and lowering of ground water levels.

In certain cases it may be acceptable to compare the proposed undertaking with a similar, previously completed project and estimates of impact magnitude may then be based on the documented impacts of the previous venture. Such an approach, however, requires that the similarities, both in the undertaking and environment, be thoroughly researched and that all differences be clearly presented.

All estimates of impact magnitude, both quantitative and qualitative, should be accompanied by an indication of their precision.

6. MITIGATIVE MEASURES, SITE/ROUTE RESTORATION, AND MONITORING

Having identified and estimated the magnitude of impacts on a site specific basis, the report should outline the strategy for implementation of selected mitigative measures, a site/route restoration plan, and an outline of construction and post-construction monitoring.

As with the identification of potential impacts, the list of mitigative measures offered should be the result of a detailed evaluation of the project design and the site specific environmental data. The estimated magnitude of impacts should also be incorporated to ensure that the resulting commitment to "good housekeeping" construction practices and installation of effective mitigative measures is tailored to the site, not merely a "standard" list.

The report must also provide some commitment by the proponent to: the monitoring and maintenance of all relevant mitigative devices, the provision of a contingency plan for unexpected events, and the rapid implementation of post construction site/route restoration to near baseline conditions or better where possible. Monitoring results are to be compared with baseline data and will indicate the effectiveness of impact mitigation and site/route restoration. An assessment can then be made regarding the need for further action.

The level of detail of this section of the EA document should be commensurate with that of the "preferred site/route data" and "description of the proposed undertaking".

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